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Deliberative and spontaneous cognitive processes associated with HIV risk behavior

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Abstract

Dual process models of decision-making suggest that behavior is mediated by a spontaneous behavior selection process or by a more deliberative evaluation of behavioral options. We examined whether the deliberative system moderates the influence of spontaneous cognition on HIV-risk behaviors. A measure of spontaneous sex-related associations (word association), a measure of deliberative working memory capacity (operation span), and two measures of sexual behavior (condom use and multiple partners) were assessed in a cross-sectional study among 490 adult drug offenders. Significant effects were observed among men but not among women in two latent interaction models. In a novel finding, the accessibility of spontaneous safe sex-related associations was significantly more predictive of condom use among men with higher working memory capacity than among men with lower capacity. These results have implications for the design of interventions to promote safe sex practices.

Keywords

Dual process; Implicit cognition; HIV risk; Decision making; Working memory capacity

Introduction

HIV risk behaviors are likely to be influenced by two cognitive processes. This dual process approach has been applied to research on decision-making across multiple disciplines including cognitive science, economics, social psychology, health behavior, and neuroscience (Bargh & Williams, 2006; Greenwald et al., 1998; Kahneman, 2003; Stacy et al., 2010; Strack & Deutsch, 2004). Studies on dual processes in decision-making have reliably demonstrated that a spontaneous cognitive process contrasts with the rational or deliberative process traditionally associated with decision-making. Spontaneous processes range from framing effects observed in survey administration to nonlinear judgments in financial decisions described by Prospect Theory (Kahneman, 2003). Despite strong evidence for dual processes in decision-making and the potential for applications to HIV prevention, few studies have examined the interplay of these processes in HIV risk behavior. The current study examines the interaction of these two processes, spontaneous and deliberative, in decisions related to HIV risk behaviors among adult drug offenders.

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Dual processes in decision-making

Cognitive processes implicated in decision-making fall along a spectrum ranging from spontaneous/implicit to deliberative/explicit (De Houwer, 2006, 2009). At one end of this spectrum, implicit processes are parallel, associative, fast, and relatively effortless (System 1: Kahneman, 2003). Implicit processes are influenced to a large extent by associations in memory. Associations related to sexual behaviors, for example, may become more accessible in memory in certain contexts (e.g., meeting new people at a bar), and the accessibility of memories for past sexual experiences can strongly influence decisions about undertaking risky behaviors. Evidence for the influence of implicit or spontaneous processes on behavior is well established in studies on appetitive behaviors including substance use in particular (for review, see Ames et al., 2006; Stacy et al., 2010; Wiers & Stacy, 2006). Examples of research in implicit cognition and sexual behavior include sexual arousal (e.g., Gillath et al., 2007; Ponseti & Bosinski, 2010), sexual orientation (Snowden et al., 2008), implicit attitudes toward close interpersonal relationships (Baldwin et al., 2010), and assessment of HIV risk in romantic relationships (Harman et al., 2009). Only a few studies have examined the influence of implicit processes on HIV risk behavior. Implicit associations toward condoms are predictive of condom use (Czopp et al., 2004) and multiple sex partner tendencies (Stacy et al., 2006b, 2000).

At the other end of the spectrum of cognitive decision-making processes, the explicit or deliberative process is serial, rule governed, slow, and effortful (System 2: Kahneman, 2003). This process relies on executive functions including maintenance of goals and options in short-term memory, retrieval of knowledge and past experience from memory, and control of attention during the decision-making process. Assessments of working memory capacity measure this ability to maintain information in an active state in the presence of interference, and working memory capacity is predictive of higher cognitive functions such as reading comprehension or verbal/spatial reasoning and is closely associated with fluid intelligence (Engle, 2002). Many traditional models of health behavior such as the health belief model describe some sort of deliberative system of reasoning (e.g., Brown et al., 1991; Rosenstock, 2000). These models have been useful guides for research and explain a portion of the variance in health behavior (Armitage & Conner, 2001), but there has been an increasing interest in application of dual process models of decision-making from basic research to health behaviors in an effort to understand a wider range of underlying processes (Stacy et al., 2010).

Theories of dual processes in decision-making propose that the two systems interact. The deliberative process, in some situations, may have the ability to monitor and moderate the influence of spontaneous processes (Bechara et al., 2006; Stacy et al., 2004; Stacy & Wiers, 2010). The environment has a range of stimuli or cues that may spontaneously evoke many associations simultaneously that are likely to compete for expression through behavior (Barrett et al., 2004). A variety of connectionist and associative memory models in basic cognitive science can explain how this occurs with respect to health behavior (Stacy & Wiers, 2006). Such spontaneous associations may be maladaptive as in the case of substance use or risky sexual behavior, or they may be adaptive as in the case of intuitions cultivated by trained experts, for example, in chess or nursing (Kahneman, 2003). In situations where competition among the alternatives meets a certain threshold, deliberative processing may be required to dampen or enhance certain behavioral options. Research on fluid intelligence, one measure of the system 2 capacity for deliberative processing, clearly demonstrates that higher deliberative capacity is associated with a range of positive life skills including success in school, employment, and avoidance of harmful behaviors (Brody, 1997; Gottfredson, 1997; Lubinski & Humphreys, 1997) suggesting that some system 2 processes operate in the interest of the individual (Stanovich & West, 2000). For example, seeing a good friend across from a busy street may spontaneously activate the desire to cross the

street to talk to the friend (System 1), but people will usually engage some deliberative processes to figure out when or where it is best to cross (System 2). In the current application of dual process theory, the general tendency of a person to protect his or her well-being may engage deliberative processing of behavioral options in situations where risky health behaviors are spontaneously activated, if the individual has sufficient System 2 capacity. Persons lower in working memory capacity, according to dual process theories, are more susceptible to spontaneous associations related to appetitive behaviors, that is, they are less capable of inhibiting these types of maladaptive spontaneous associations and may appear to act in an irrational, self-destructive manner engaging in risking health behaviors (Stacy & Wiers, 2010). Regardless of the specific deliberative processes, dual process theories propose that spontaneous and deliberative processes interact in the determination of behavior.

This type of interaction has been observed in racial bias (Payne, 2005), problem solving (De Neys, 2006), food choice (Hofmann et al., 2007), substance use (Finn & Hall, 2004; Grenard et al., 2008; Houben & Wiers, 2009; Thush et al., 2008), and sexual interest measured among males (Hofmann et al., 2008). In the case of substance use, Grenard et al. (2008) found that the influence on substance use by spontaneous alcohol-related or tobacco-related associations (word association) among at-risk adolescents in the US was moderated by working memory capacity (Self-Ordered Pointing Task). The strength of the substance-related associations was more predictive of substance use among those lower relative to those higher in working memory capacity. Thush et al. (2008) replicated these results in Holland among a sample of adolescents using a different measure of spontaneous associations (Implicit Association Task). Houben & Wiers (2009) also found evidence of a moderating effect of impulse control (Stroop Task) in the deliberative system on the association between spontaneous associations and drinking behavior among university students in Holland. The results of these studies show that the strength of implicit associations related to a behavior are more predictive of that behavior for those lower than for those higher in the capacity for deliberative processing (e.g., working memory capacity). These findings are highly relevant to design considerations for interventions to prevent HIV risk behavior due to individual differences in risk based upon both memory associations and the capacity for deliberative or executive control.

The current study

The current study examined the interaction of spontaneous processes with the capacity for deliberative processing. We hypothesized that working memory capacity would moderate (dampen) the influence of spontaneously activated, casual sex-related associations in memory such that the accessibility of sex associations would be more predictive of HIV risk behavior for those lower in working memory than for those higher in working memory. In a second and exploratory hypothesis, we proposed that working memory capacity would moderate (enhance) the influence of spontaneously activated safe sex-related associations in memory such that the accessibility of safe sex associations in memory would be more predictive of safe sex behaviors for those higher in working memory than for those lower in working memory. We reasoned that if deliberative processes can dampen the influence of spontaneous, risky associations on engaging in risky behavior as seen across a range of behaviors, then deliberative processes may also be capable of enhancing the influence of spontaneous, adaptive associations on engaging in a safe behavior. Associations related to having casual sex and related to using condoms may be spontaneously activated at the same time in certain contexts, and deliberative processes may be needed for an individual to choose a healthy option, to avoid having casual sex (dampen the influence of associations related to having casual sex) or to use condoms (enhance the influence of associations related to condom use). This does not imply a main effect of deliberative processing on

spontaneous associations or accessibility but rather suggests an interaction in which such processing influences the *application* of spontaneous associations. The underlying notion is that higher working memory capacity should lead to more adaptive application of spontaneous associations, dampening effects of spontaneous but potentially hazardous associations on behavior and strengthening the effects of healthier associations.

Methods

Participants

Adults enrolled in drug diversion/education programs in Southern California in 2009 and 2010 were recruited for the study. These programs provide drug education services for drug offenders in lieu of prosecution for a variety of drug-related offenses such as the sale or possession of an illegal substance or driving under the influence. A total of 490 individuals attending these programs agreed to participate in the assessments. Out of those participating, five were dropped from the sample for missing gender data that was necessary for multigroup analysis. The final number of participants included in the analysis was 485.

Procedures

Data collectors obtained approval from administrators of the drug division programs in advance to recruit participants and to administer computer-based assessments in a separate room in the program facility. Twelve laptop computers were set up in the room before recruiting participants. Data collectors distributed informed consent forms and read the information to those in the drug diversion class. Potential participants were assured that the survey would be completely anonymous and that a Certificate of Confidentiality issued by the National Institutes of Health would block law enforcement agencies from gaining access to the data. Participants indicated their consent verbally prior to taking the computer-based assessments, which were developed to be self-administered by the participants. It required 60–90 min to complete the tasks and participants were reimbursed $15 for their time. The University Institutional Review Board approved all procedures.

Measures

Spontaneous/implicit associations—Word association tests measured spontaneous associations related to HIV risk behaviors (Stacy, 1997; Stacy et al., 2006a). The tests elicited open-ended responses to a series of 33 cue words and phrases presented one at a time on the computer screen. Participants were asked to type the first behavior or action that came to mind for each cue in a manner similar to verb generation tasks (Seger et al., 1999; Stacy, 1997). The task was completed at the beginning of the assessment prior to drug or sexual behavior assessments to prevent priming effects. Word association cues included words and phrases that were previously generated by similar populations of participants (Stacy et al., 2006b, 1996; Sussman et al., 1998). These cues included outcomes of drug use or having sex (e.g., feeling good), situations associated with drug use or sex (e.g., Friday night), phrases combining situations and outcomes (e.g., Friday night, feeling good), and neutral filler cues not expected to elicit drug or sex-related responses (e.g., Thursday morning). No cues mentioned sex or its synonyms, thus providing an indirect assessment of associations with sex. Cues were presented in a randomized order with the constraint that a neutral cue would be presented after each of three target cues to reduce chaining effects.

Word association responses were self-coded by participants after they completed the association task. Each cue and their associated response was presented on the computer screen one at a time along with at list of 14 categories (e.g., ‘playing sports’,’ alcohol’, ‘marijuana’, ‘exercise or workout’, ‘casual sex/one night stand’, ‘safe sex’, ‘food or diet-related’ ‘methamphetamine’,’ other drugs’, ‘sleeping’, ‘cocaine’, ‘AA or NA’, ‘sex with

main partner', 'none of the above'). Participants selected one or more categories, and the categories were scored with a '1' if selected and '0' if not selected. The sum of coded responses for a category provided an indication of the strength or accessibility of associations in memory for that category (Stacy, 1997). The two target categories in the current study were 'casual sex/one night stand' and 'safe sex', and the scores for each category were used in two separate models to predict sex-related behaviors. Frigon & Krank (2009) successfully demonstrated concurrent validity for self-coding with coding by independent judges and that self-coding improved criterion validity on this task over coding by judges.

Working memory capacity—The Automated Operation Span Task measured executive control of attention under interference (Unsworth et al., 2005). Participants observed a series of 2–5 letters presented on the screen and attempted to recall the letters in the sequence presented. Math problems presented between each letter provided distraction from the recall task thereby assessing the degree to which participants could control their attention to maintain the series of letter in working memory while completing the distracter task. Each set of 2, 3, 4, and 5 letters was presented in three replications for a total of 12 trials (alpha = 0.79). The score for each trial was '0' if all the letters presented were not remembered in the correct order, or the trial score was equal to the number of letters in the trial if they were all recalled in the correct order. The scores for the trials were randomly assigned to three parcels that were used as indicators for a latent working memory factor (see "Analysis").

Measures of HIV risk behaviors—*Multiple sex partners* included five items asking about the number and types of sex partners (e.g., main, casual, exchange) in the last 4 months. A number of researchers including the Centers for Disease Control used similar measures to assess HIV-risk behavior (Reilly & Woo, 2001; Richardson et al., 2004; Stacy et al., 2006a). A higher score indicted more partners and higher HIV-risk (alpha = 0.87). *Condom Use* was assessed using three items taken from the HIV Risk-Taking Behavior Scale (Darke et al., 1991; Donenberg et al., 2001). The questions asked how often participants used condoms in the past 4 months when having vaginal, oral, or anal sex. A higher score indicated more frequent use of condoms (alpha = 0.73).

Covariates—Measures of *Drug Use* included individual drug use items from a validated scale for the frequency of substance use (Graham et al., 1984). In the current study, the frequency of using alcohol, marijuana, and methamphetamine/speed in the past 4 months were assessed using a 10-point scale ranging from '0 = 0 times' to '9 = 99 + times'. Measures of *Participant Characteristics* included items assessing age, gender, race, ethnicity (Hispanic or not), SES (education as a proxy), and a language-based proxy for acculturation (Marin et al., 1987).

Analysis

Descriptive statistics were determined for the participant characteristics, drug use, multiple partners, and condom use. Following that, we constructed two latent interaction models. The first model included the strength of casual sex-related associations in memory, working memory capacity, and the interaction of these two constructs in the prediction of multiple sex partners. The second model included the strength of safe sex-related associations in memory, working memory capacity, and the interaction of these two constructs in the prediction of condom use. Prior to fitting the latent interaction models, we fit measurement models to assess the hypothesized relationships among indicators and their factors and to determine if there were any unexpected cross-factor loadings. Individual trials for the word association tests (22 target responses total) and for the working memory task (12 trials total) were summed to form three parcels for each measure that were used as indicators for each

factor. The formation of parcels from individual items is a well established procedure in structural equation modeling that is used to manage the number of items on each factor and to improve model stability (Little et al., 2002). In addition, creating the parcels facilitated formation of the indicators for the latent interaction.

We also assessed measurement invariance across gender using the measurement model (Pentz & Chou, 1994; Teresi, 2006) to assess whether the measurement items had similar meaning for men and woman. Although we did not hypothesize a difference by gender for the moderation effect, we chose to test, in the interest of due diligence, whether the measures were invariant across gender and whether the hypothesized effects were similar in the moderation models for men and women. Our analytical approach here was informed by previous research that suggests possible differences in sexual behavior between men and women (e.g., Abbey et al., 2006; Geer & Robertson, 2005; Rosenthal & Levy, 2010).

The latent interaction models were fit using the unconstrained latent interaction approach (Marsh et al., 2004, 2007) in a two-group by gender model using Mplus software (Muthen & Muthen, 1998–2010). This unconstrained approach to interaction modeling has consistently performed well in simulation research (Klein & Muthén, 2007; Marsh et al., 2004, 2007) and has been successfully applied to health behavior research. (e.g., Keller et al., 2009). In this approach, the products of the indicators for the latent factors are used as indicators on the interaction latent factor. No constraints are placed upon the model parameters. We included age, ethnicity, acculturation, and substance use as covariates in both models to adjust for possible confounding of the hypothesized relationships by these variables. The Mplus software default procedure for missing data, full information maximum likelihood, was utilized in these analyses (Schafer & Graham, 2002). The fit of the measurement and the structural models was assessed using standard goodness-of-fit indices including the Chi-square goodness-of-fit indices, Tucker-Lewis index (TLI), comparative fit index (CFI), and the root mean square error of approximation (RMSEA) and its confidence interval (Marsh et al., 2005).

Results

Participants in the analysis sample included 353 (72.78%) men and 132 (27.22%) women with the overall mean age of 31.81 (SD = 10.79) and a range of 18–66 years (see Table 1). A total of 236 (49.27%) self-reported their ethnicity to be Hispanic. The majority of the participants reported using English only or more than any other language (86.60%) and women reported using English more than men. The overall mean score for working memory capacity was 22.21 (SD = 11.74, range 0–42), and women had a significantly lower score than men. Although there is evidence that drug use can negatively impact working memory capacity depending upon the drug, quantity, and duration of use (Gouzoulis-Mayfrank et al., 2000; Lundqvist, 2005), our results indicate that there was a good range of working memory capacity scores among our sample of participants. Further, there was no significant correlation between hard drug use and working memory capacity in the sample ($r = 0.056$, $p = 0.28$). The prevalence of drug use in the past 4 months was 60.82% for alcohol, 36.91% for marijuana, and 29.69% for methamphetamine/speed. Women reported significantly more meth/speed use than men. The prevalence of having multiple partners (i.e., more than one partner) in the 4 months was 58.35%, and the prevalence of condom use greater than 50% of the time in the past 4 months was 29.90%. There was no significant difference by gender in self-reports for the prevalence of having multiple partners or using condoms.

Measurement models

The measurement models were used to examine the factor loadings, factor cross-loadings, and measurement invariance of the latent variables across gender for the two latent

interaction models, one predicting multiple partners and one predicting condom use. First, we observed that indicators loaded well on their hypothesized latent variables in separate models for men and women (total of four measurement models), and examination of a priori hypothesized modification indices for cross-factor loadings provided evidence for simple structure (i.e., indicators loading solely on their hypothesized factor). Second, we tested measurement invariance across gender for each of the two latent interaction measurement models. For each multi-group model, the fit indices obtained when parameters were unconstrained across gender were compared to the fit indices when factor loadings and thresholds were constrained across gender. Constraints were relaxed where necessary to maintain a non-significant difference between the unconstrained and constrained models as measured using the Chi-square difference test. There was an adequate fit for both unconstrained, multiple partners model (fit indices: $\chi^2(82) = 174.450$, $p < 0.001$; CFI = 0.94; TLI = 0.93; RMSEA = 0.071, 95%CI [0.056, 0.085]) and the unconstrained, condom use model (fit indices: $\chi^2(48) = 59.242$, $p < 0.3$; CFI = 0.99; TLI = 0.98; RMSEA = 0.033, 95%CI [0.000, 0.057]). The model for multiple partners required the relaxation of a constraint on one factor loading on an indicator for the spontaneous association factor and relaxation of a constraint on one threshold for an indicator on the factor for multiple partners (final Chi-square difference = 3.642, $p = 0.06$). The model for condom use also required the relaxation of a constraint on one factor loading for the association factor and the thresholds for two indicators on the condom use factor (final Chi-square difference = 4.009, $p = 0.05$).

In practice, it is often difficult to obtain complete measurement invariance where all of the items in a measure are equivalent in factor loadings and intercepts across groups (Byrne et al., 1989; Steenkamp & Baumgartner, 1998). Strict invariance is not necessary in situations, such as the current study, where basic research is used to examine the relative strength of associations across gender (Byrne et al., 1989; Millsap & Kwok, 2004; Steenkamp & Baumgartner, 1998). Byrne et al. (1989) argued that as long as one item (in addition to the indicator item for which the factor loading is fixed at 1.00 to establish the factor measurement scale) was invariant across groups, structural model evaluation could proceed where group level factor means (but not the raw score means) are to be compared (also see, Gregorich, 2006; Steenkamp & Baumgartner, 1998). Relaxing the constraints in the current models was well within the requirements for demonstrating partial measurement invariance by gender to meet the current analysis objectives (Borsboom, 2006; Gregorich, 2006). The two measurement models for multiple partners and condom use each fit the data well: CFI > 0.93, TLI > 0.93, and RSMEA ≤ 0.06.

Latent interaction models

The first of two interaction models was fit to the data such that a latent factor for multiple partners was regressed on a spontaneous casual sex-related memory association factor, a working memory factor, the interaction between the two latent factors, and a number of potential confounders (age, Hispanic ethnicity, education as a proxy for SES, language acculturation, and drug use). Men and women were included as separate groups in the multi-group model. Initially, regression coefficients in the structural model were constrained across gender to be equal, and then specific constraints were relaxed based upon modification indices and model fit indices. The resulting model shown in Fig. 1 fit the data well (fit indices: $\chi^2(414) = 514.243$, $p < 0.001$; CFI = 0.94; TLI = 0.93; RMSEA = 0.033, 95%CI [0.022, 0.042]).[1] There was a significant interaction between the casual sex-related memory association factor and the working memory factor ($b = -0.155$, SE = 0.093, $p = 0.048$ single tail) among men but not among women ($b = 0.008$, SE = 0.218, $p = 0.49$). Other significant regression paths included multiple partners on the association factor for men but not women, and multiple partners on several covariates including marijuana use

(men but not women), meth/speed use (women but not men), and acculturation (both men and women).

Interpretation of the interaction was assisted by plotting the simple curves for multiple partners versus spontaneous casual sex-related associations for men at the mean and at plus and minus one standard deviation for the working memory capacity scores (Aiken & West, 1991). As hypothesized, the strength or accessibility of casual sex-related associations in memory as measured with the word association tests is more predictive of having sex with multiple partners among those with lower working memory capacity than among those with higher working memory capacity (see Fig. 2a). The interaction term accounted for 1.7% of the variance (R^2) in condom use among men, and the overall model accounted for 13.4% of the variance among men in condom use and 18.8% among women.

The second interaction model was fit to the data such that a latent factor for condom use was regressed on a spontaneous safe sex-related memory association factor, a working memory factor, the interaction between the two latent factors, and a number of potential confounders (age, Hispanic ethnicity, education as a proxy for SES, language acculturation, and drug use). Men and women were included as separate groups in the multi-group model. Initially, regression coefficients in the structural model were constrained across gender to be equal, and then specific constraints were relaxed based upon modification indices and model fit indices. The resulting model shown in Fig. 3 fit the data well (fit indices: $\chi^2(261) = 352.970$, $p < 0.001$; CFI = 0.92; TLI = 0.89; RMSEA = 0.039, 95%CI [0.028, 0.050]). There was a significant interaction between the spontaneous safe-sex memory association factor and the working memory factor ($b = 0.198$, SE = 0.086, $p = 0.011$ single tail) among men but not among women ($b = -0.015$, SE = 0.127, $p = 0.42$). Other significant regression paths included condom use on the association factor for both men and women, and condom use on several covariates including age as a dummy variable by quartiles (men and women), alcohol use (men and women), and marijuana use (men and women).

As with the previous model, interpretation of the interaction was assisted by plotting the simple curves for condom use versus spontaneous safe sex-related associations for men at the mean and at plus and minus one standard deviation for the working memory capacity scores (Aiken & West, 1991). As hypothesized, the strength or accessibility of safe sex-related associations in memory as measured with the word association tests is more predictive of using condoms among those with higher working memory capacity than among those with lower working memory capacity (see Fig. 2b). The interaction term accounted for 3.2% of the variance (R^2) in condom use among men, and the overall model accounted for 22.0% of the variance in condom use among both men and women.

Discussion

The results in this study are consistent with dual process models of decision-making that propose an interaction between the spontaneous/implicit system and the deliberative/explicit system. Consistent with our first hypothesis, the data show a moderation (dampening) effect of working memory capacity on risk-related associations. The accessibility of casual sex-

[1]Note that the loadings on the indicators for the latent interaction are not as homogenous as might be desired. However, the indicators in the XZ factor are product terms, that is, products multiplying one variable by another, and the reliability of a product term is influenced by the reliability of each term (Bohrnstedt & Marwell, 1978; Dunlap & Kemery, 1988). Such multiplicative products are rarely if ever as homogenous as indicators of first order factors. It is somewhat surprising that they can be as homogenous as they are, given the mathematics—the upper bound correlation of products (and factor loadings of product terms) is usually much less than when using regular indicators. The common variance of the products, reflected in the factor, is the chief concern in these analytic models, however, and the procedure used to prepare the product terms for the latent interactions in this study has been thoroughly tested in simulation studies (Marsh et al., 2004, 2007).

related associations is more predictive of having multiple sex partners among those with lower working memory capacity than among those with higher working memory capacity. This type of interaction between systems is consistent with proposed models of dual process interactions (Bechara et al., 2006; Stacy et al., 2004; Stacy & Wiers, 2010) and with other studies in appetitive behaviors such as substance use (Finn & Hall, 2004; Grenard et al., 2008; Houben & Wiers, 2009; Thush et al., 2008). Consistent with our second hypothesis, the accessibility of safe sex-related associations in memory is more predictive of using condoms among those with higher working memory capacity than among those with lower working memory capacity. The current study is the first of which we are aware that has demonstrated this moderation (enhancement) effect of working memory capacity on the association between implicit cognition (spontaneous safe sex-related associations) and health behavior (condom use) in a dual process model of HIV risk behaviors.

These moderation effects were significant among men but not among women in each of the two-group models. It is likely that this is due to the relatively smaller sample of women affecting the power to detect the interaction although other influences are possible. For example, the women in this sample tested significantly lower in working memory capacity than men and used more methamphetamine than men. These differences between women and men may have contributed to the apparent lack of ability among the women in this study to use deliberative processes to moderate the effects of spontaneous associations.

The results for the novel finding of a moderation (enhancement) effect may be examined in terms of a dual process model of decision-making. It is likely that multiple associations in memory related to sexual behaviors, some related to risky behaviors and some related to protective behaviors, are spontaneously activated in the presence of certain contexts or cues with varying associative strengths (i.e., parallel processing in System 1: Kahneman, 2003). It may be that higher working memory capacity provides the opportunity and the control of attention resources to consider behavioral options despite interference from multiple associations evoked by environmental stimuli. If associations are risky, their effects can be suppressed or at least dampened, as argued earlier. If associations are more adaptive, their effects may be enhanced through better control of competing associations or interference. In both instances, higher working memory capacity facilitates more fluid and adaptive processing resistant to interference from other sources. This reliance on working memory capacity may be even more critical among recovering drug offenders who are trying to use limited deliberative resources to manage the influence of spontaneous associations related to both substance use and sexual behaviors.

Predictive effects of working memory capacity were only revealed through moderator (interaction) effects, not through first order effects of working memory capacity on behavior. This is important because it suggests that simply modeling main or direct effects of working memory (and perhaps other executive functions) on behavior is insufficient. Consistent with previous research cited earlier (e.g., Finn & Hall, 2004; Grenard et al., 2008; Hofmann et al., 2008; Houben & Wiers, 2009; Payne, 2005), dual process model effects are best investigated and theorized in terms of synergistic effects.

It should be emphasized that spontaneous associations had significant first order, direct effects in both analytic models, revealing relevant effects on condom use as well as multiple partners. Direct effects (of spontaneous associations or working memory) in an interaction model of this nature need great care in interpretation. They are direct effects adjusting for the latent interaction terms, which are parameterized by loadings on product terms. This adjustment also occurs in traditional moderated regression (Cohen et al., 2003). Nevertheless, it is informative to consider these effects before and after adjustment of latent interactions. These spontaneous association effects were significant for both males and

females in the model for condom use and for males in the model for multiple partners. The same pattern of significant direct effects was observed before adjustment of the models with the latent interaction terms. Such significant effects are consistent with many previous studies, and underscores that these implicit associations play an essential role in the significant interactions already discussed. The finding of an important role for spontaneous associations (System 1 processing) is consistent with a growing body of findings in health behavior, including alcohol and other drug abuse (for review, see Ames et al., 2006; Stacy et al., 2010; Wiers & Stacy, 2006), diet (Craeynest et al., 2005; Hollands et al., 2011), exercise (Banting et al., 2009; Hyde et al., 2010), and sexual behavior (Baldwin et al., 2010; Gillath et al., 2007; Ponseti & Bosinski, 2010; Stacy et al., 2006b, 2000). The findings are also consistent with several decades of basic research revealing the underlying neural systems of automatic or implicit processes (Bechara, 2001; Franken et al., 2006; Ruff et al., 2008). However, this consistent research still has not received widespread attention in behavioral medicine, public health, or related fields compared to traditional theories of health behavior, despite major meta-analytic findings revealing the importance of investigating System I processes (Rooke et al., 2008).

Findings consistent with dual process models as well as the importance of spontaneous processes may suggest certain approaches to interventions that reduce HIV risk behavior. Approaches for enhancing deliberative processing may continue to apply traditional methods of training in decision-making related to health (e.g., Sussman et al., 2004) or may use more recent techniques shown to improve working memory capacity (Morrison & Chein, 2011). Intervention approaches designed to influence the spontaneous/implicit system may need to develop new associations in long-term memory that associate risky environmental cues with safe-sex behaviors such as using condoms. These protective behaviors need to be evoked by contextual stimuli when the decision is made to engage in a risky or a protective behavior (Stacy & Wiers, 2010; Wood et al., 2005). Whatever approach is taken, there is increasing evidence that individual differences in spontaneous and deliberative processes influence behaviors, and it may be useful to account for these differences when designing interventions.

It should be noted that although the amount of variance explained by the interaction effects was small, this is typically the case for moderation effects observed in field studies (McClelland & Judd, 1993). Normal distributions around the means for independent variables in observational field studies limit moderation effect sizes when compared to experimental lab studies where subjects are often preselected into groups that have high or low levels of moderating variables. This relatively small effect size of the interactions, however, does not diminish the fact that an important proportion of those lower in working memory capacity are at higher risk of HIV infection. More recent trends toward interventions that are tailored to individuals (e.g., Noar et al., 2007) should provide an opportunity to address the needs of these individuals, and the current results should help inform these types of interventions among others. Further, additional important levels of variance were explained by the combination of direct effects of spontaneous associations coupled with moderated effects, as discussed earlier.

There is some evidence that indirect measures of implicit associations may be influenced by context effects (Krank et al., 2005; Lindgren et al., 2009; Mitchell et al., 2003; Roefs et al., 2006). It appears that the strength of associations measured in a lab may be less than those measured in more natural environments. It is possible that measuring spontaneous associations related to sex in the drug diversion program facilities may have underestimated the strength of these associations that occur in contexts where behaviors related to sex are more salient (e.g., in a bar). It is not clear how the measurement context might influence the observed moderation effects, but it is likely that these more naturally occurring contexts may

put a higher load on working memory. Stronger spontaneous associations and an overloaded working memory seem likely to increase the probability of risky sexual behavior based upon the results of the current study.

The current study has several limitations. First, the data are cross-sectional and the ability to infer causality is limited. Second, the results may be generalized only to persons similar to the drug offenders assessed in the current study, but it is clear from the data that this population engages in sex-related behaviors that place themselves and others at greater risk of contracting or transmitting the HIV virus and other sexually transmitted diseases. Finally, it is always difficult to rule out third variable effects such that an unmeasured variable could explain the associations observed in the current analysis. For example, those higher in working memory capacity may have more sophisticated health goals that could influence the moderation effects. However, the results obtained in the current study in combination with other studies cited previously on dual process interactions provide evidence consistent with dual process models that describe the interplay of spontaneous associative processes with deliberative/executive control processes.

Conclusion

The current study provides additional support to the expanding literature on the interaction of the dual processes in decision-making by extending these findings to the area of HIV risk behavior. The results are consistent with dual process models of decision-making in that a higher capacity for deliberative processing moderates or dampen the influence of spontaneous sex-partner associations on having multiple sex partners. In an important novel finding, a higher working memory capacity is also associated with moderating or enhancing the influence of spontaneous safe sex-related associations on the use of condoms. These findings have implications for the design of interventions suggesting that efforts to develop new health-promoting associations linked in memory to environmental cues and/or training in decision-making and working memory capacity may be effective depending upon individual differences.

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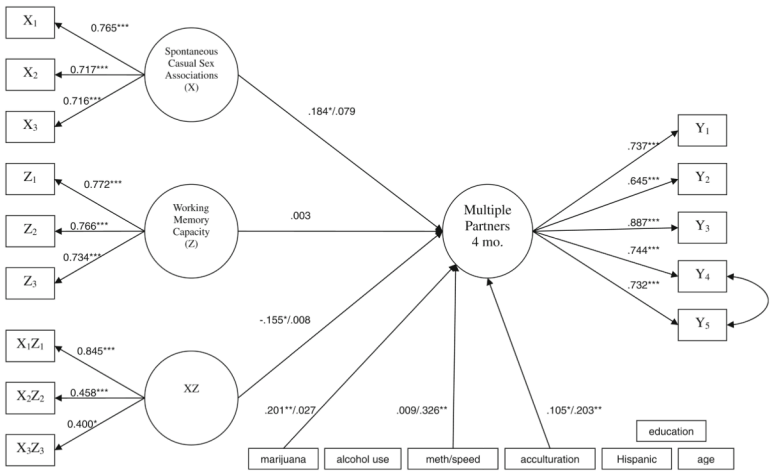

Fig. 1.

Latent interaction model with multiple partners regressed on spontaneous casual sex-related associations and working memory capacity. Model fit: Chi-sq = 514.243, $df = 414$, $p < 0.001$; CFI = 0.943, TLI = 0.934, RMSEA = 0.033 (95%CI: 0.022, 0.042). Factor loadings and regression coefficients were constrained to be equal across gender except where unconstrained estimates significantly improved the model fit (Chi-square difference test, $p > 0.05$). Standardized estimates (constrained or male/female), one-tailed p values for regression coefficient estimates: $^{\dagger}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$. Estimates for non-significant covariates are not shown for clarity

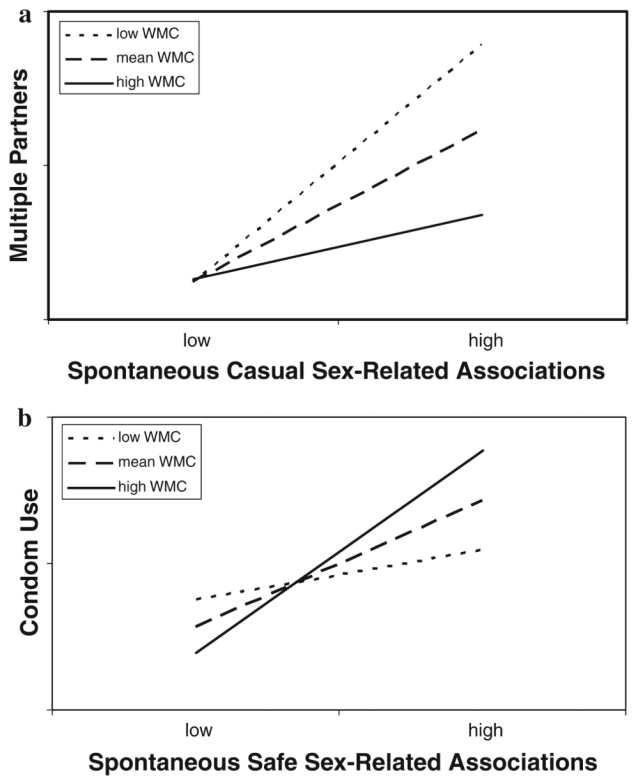

Fig. 2.

Plots of simple curves for the significant latent interactions among males: **a** multiple partners regressed on spontaneous casual sex-related associations and working memory capacity (WMC) and **b** condom use regressed on spontaneous safe sex-related associations and working memory capacity (WMC). Notes on the simple curves: *Low WMC* = working memory capacity at the mean minus one standard deviation; mean *WMC* = working memory capacity at the mean; *high WMC* = working memory capacity at the mean plus one SD

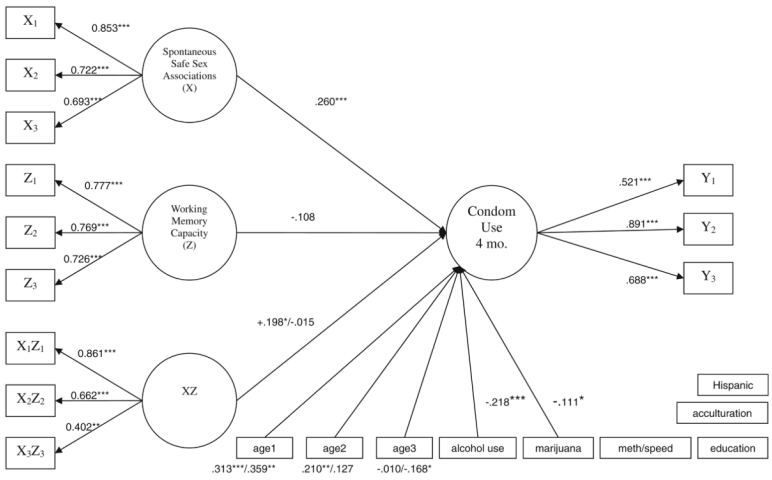

Fig. 3.

Latent interaction model with condom use regressed on spontaneous safe sex-related associations and working memory capacity. Model fit: Chi-sq = 352.970, *df* = 261, $p < 0.001$; CFI = 0.925, TLI = 0.887, RMSEA = 0.039 (95%CI: 0.028, 0.050). Factor loadings and regression coefficients were constrained to be equal across gender except where unconstrained estimates significantly improved the model fit (Chi-square difference test, $p > 0.05$). Standardized estimates (constrained or male/female), one-tailed *p* values for regression coefficient estimates: $^{\dagger}p < 0.10$; $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Estimates for non-significant covariates are not shown for clarity

Table 1

Participant characteristics

Item	All	Men	Women	Gender difference	
				t value or Chi-square (*df*)	*p* value
Gender % (*N*)	100 (485)	72.78 (353)	27.22 (132)		
Age *M* (SD)	31.81 (10.79)	31.54 (10.77)	32.52 (10.88)	0.86 (460)	0.388
Hispanic % (*N*)	49.27 (236)	47.85 (167)	53.08 (69)	1.03 (1)	0.309
Race % (*N*)					
Native American/Alaska Native	5.19 (20)	5.40 (15)	4.67 (5)	8.58 (5)	0.127
Asian	2.08 (8)	2.52 (7)	0.93 (1)		
Native Hawaiian/Pacific Islander	1.30 (5)	1.80 (5)	0.00 (0)		
Black	3.90 (15)	3.60 (10)	4.67 (5)		
White	83.12 (320)	83.81 (233)	81.31 (87)		
Mixed	4.42 (17)	8.41 (8)	2.88 (9)		
Acculturation (English used only or more than another language)	86.60 (420)	84.70 (299)	91.67 (121)	4.01 (1)	0.045
Education (high school diploma or greater)	82.06 (398)	84.14 (297)	76.52 (101)	3.79 (1)	0.052
Working memory capacity M(SD)	22.21 (11.74)	23.19 (11.92)	19.60 (10.89)	− 3.02 (481)	0.003
Prevalence of alcohol use past 4 months	60.82 (295)	60.06 (212)	62.88 (83)	0.32 (1)	0.571
Prevalence of marijuana use past 4 months	36.91 (179)	36.54 (129)	37.88 (50)	0.07 (1)	0.786
Prevalence of methamphetamine/speed use past 4 months	29.69 (144)	24.93 (88)	42.42 (56)	14.09 (1)	< 0.001
Prevalence of multiple partners (>1 partner past 4 months)	58.35 (283)	57.22 (202)	61.36 (81)	0.68 (1)	0.410
Prevalence of condom use (≤ 50% of the time during vaginal sex in past 4 months)	29.90 (145)	30.03 (106)	29.55 (39)	0.01 (1)	0.918